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(54) **MAINTENANCE OF UNIFORM IMPEDANCE PROFILES BETWEEN ADJACENT CONTACTS IN HIGH SPEED GRID ARRAY CONNECTORS**

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(51) **Int. Cl.**
H01R 13/42 (2006.01)

(52) **U.S. Cl.** **439/751**; 439/733.1; 439/873

(58) **Field of Classification Search** 439/751, 439/873, 733.1, 720, 736
See application file for complete search history.

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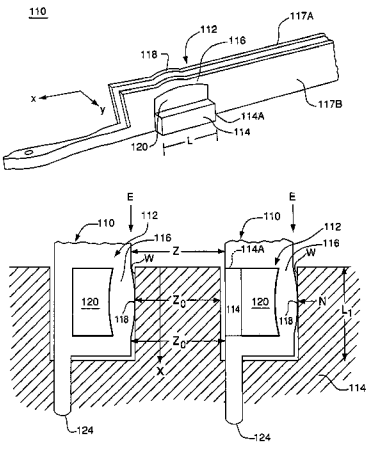
(57) **ABSTRACT**

An electrical contact that is particularly suitable for use in high speed, grid array connectors is disclosed. The contact includes a retention member extending along a length thereof. The retention member is adapted to retain the contact within a connector base and to deform upon insertion of the contact into the base to cause a generally straight edge to be formed along a portion of the contact that includes the length along which the retention member extends. Thus, a generally uniform impedance profile may be created between adjacent contacts along the respective portions that are inserted into the connector base.

16 Claims, 6 Drawing Sheets



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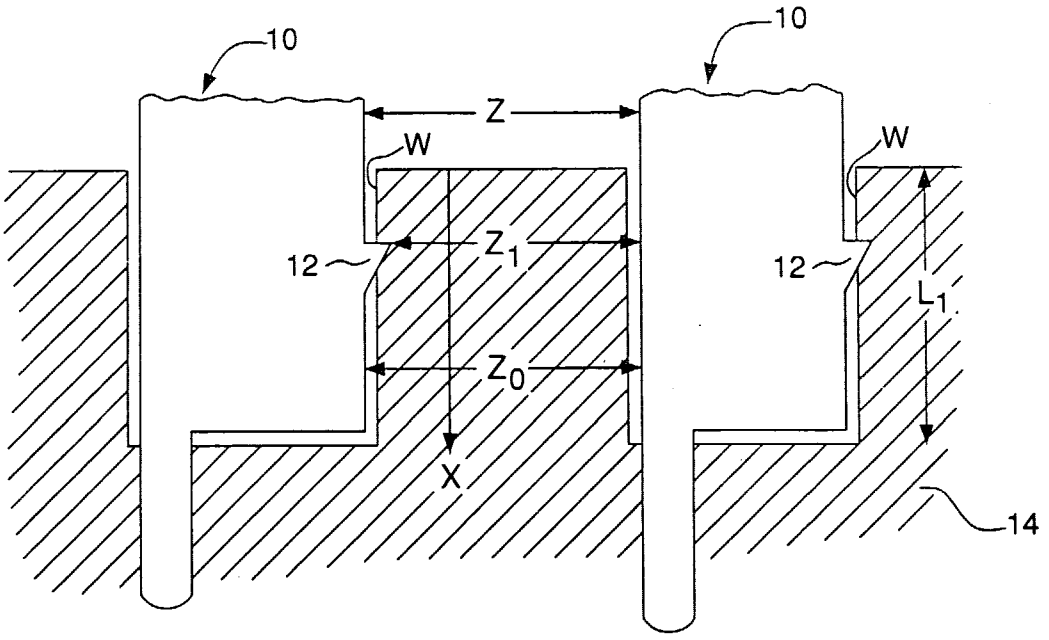


FIG. 1
(PRIOR ART)

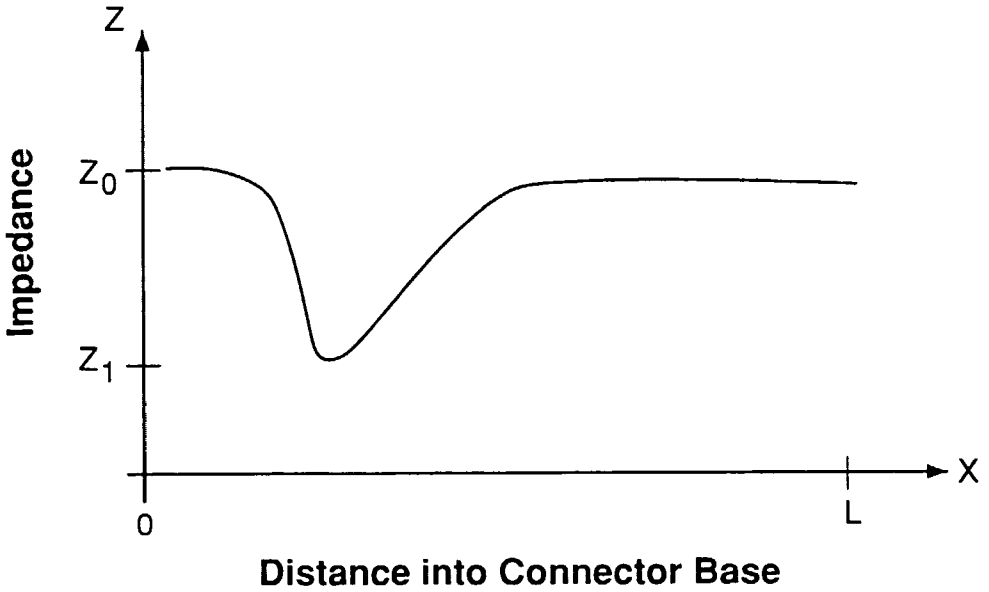


FIG. 2
(PRIOR ART)

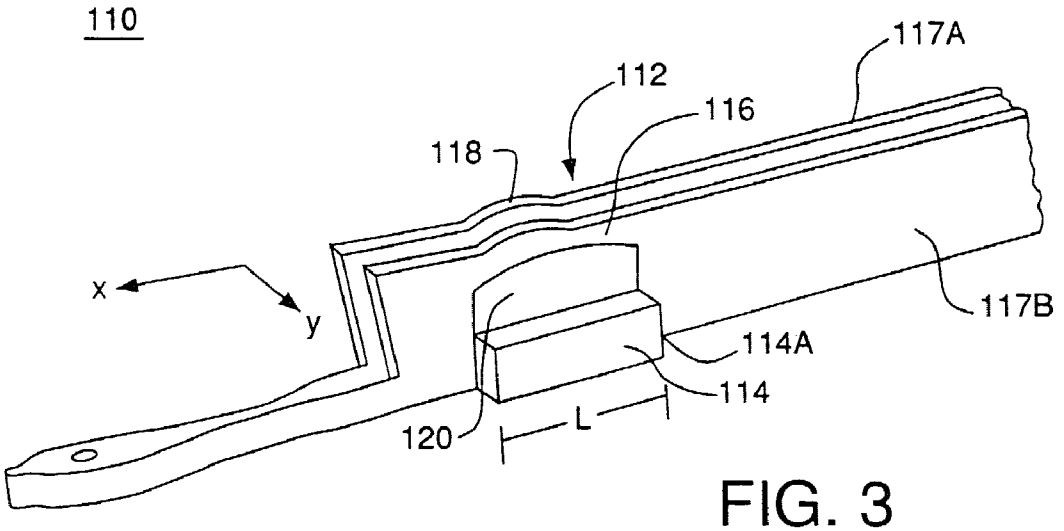

110
117A
112
116
118
x
y
117B
114A
114
120
L

FIG. 3

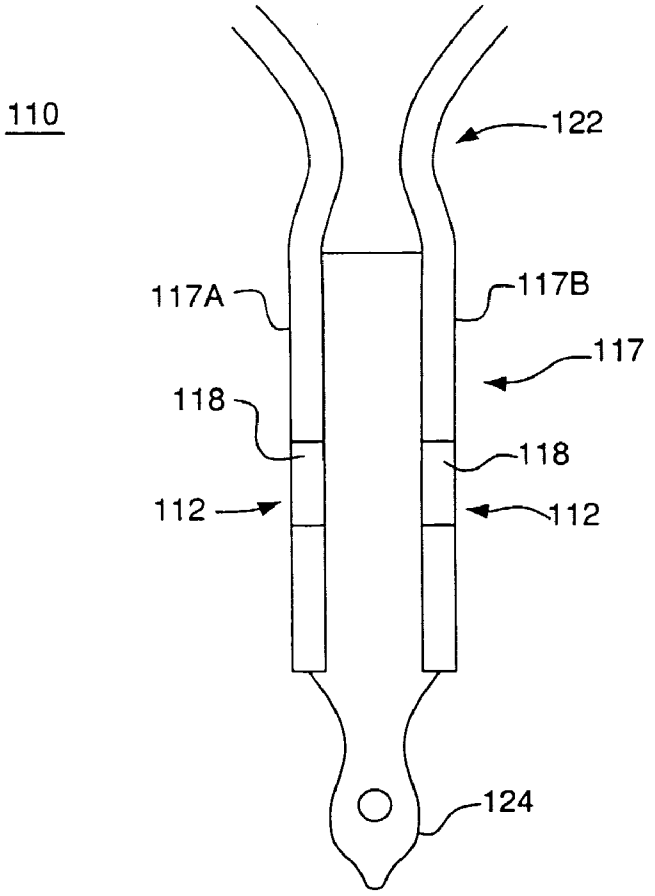

110
122
117A
117B
117
118
118
112
112
124

FIG. 4

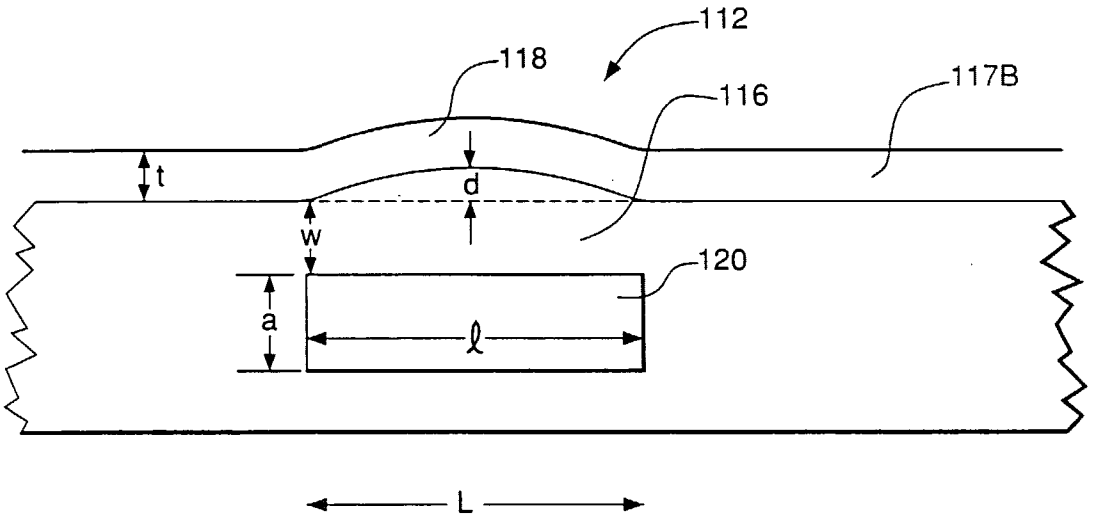


FIG. 5

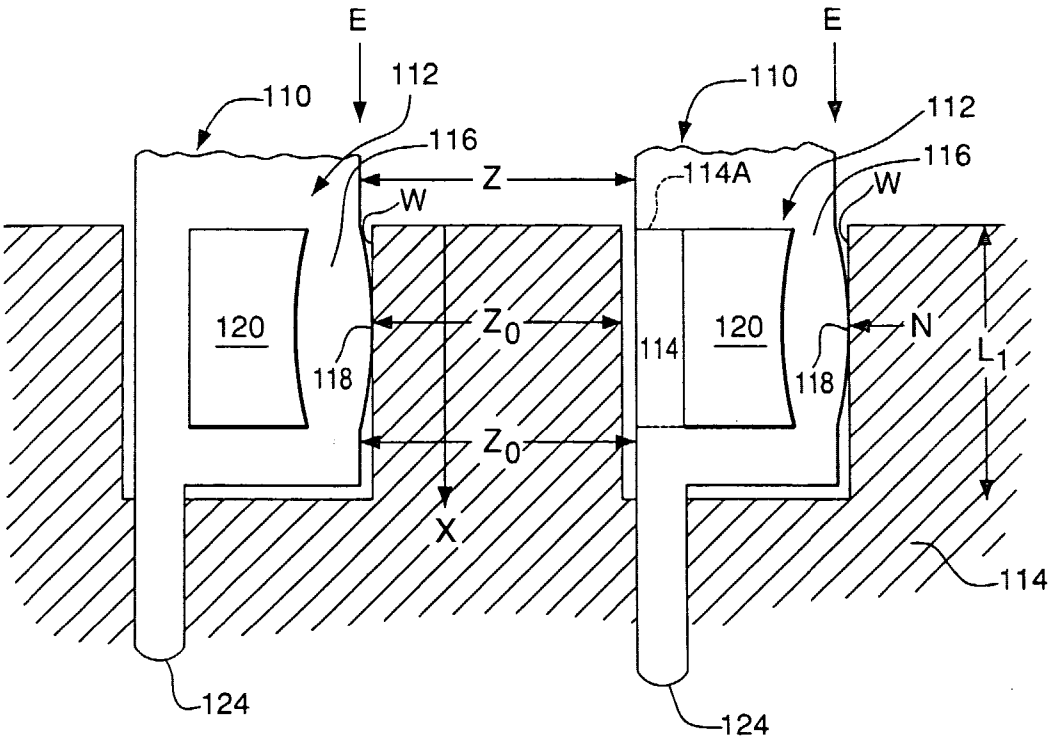

E
112
110
116
Z
W
114A
120
Z_0
118
114
N
L_1
X
124

FIG. 6

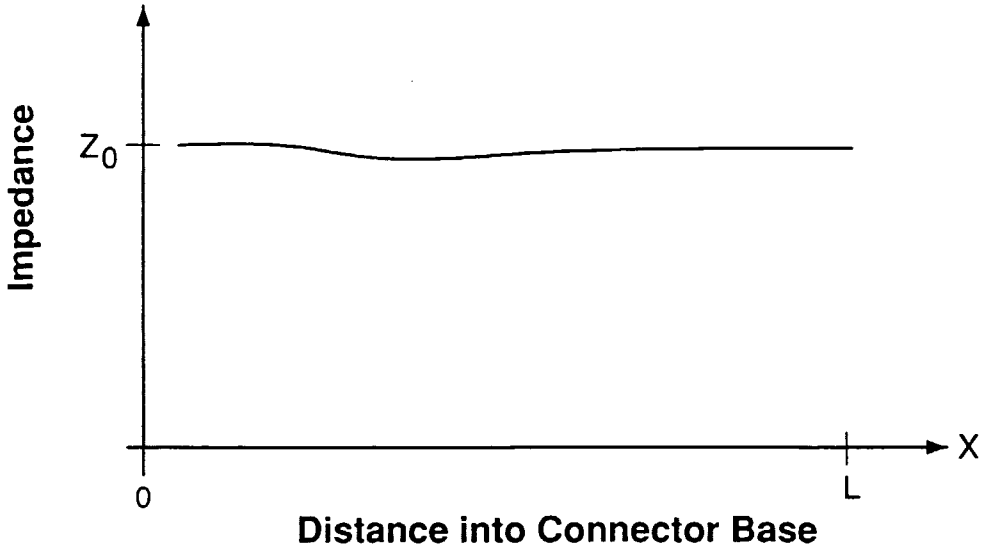

Impedance
Z_0
X
0
L
Distance into Connector Base

FIG. 7

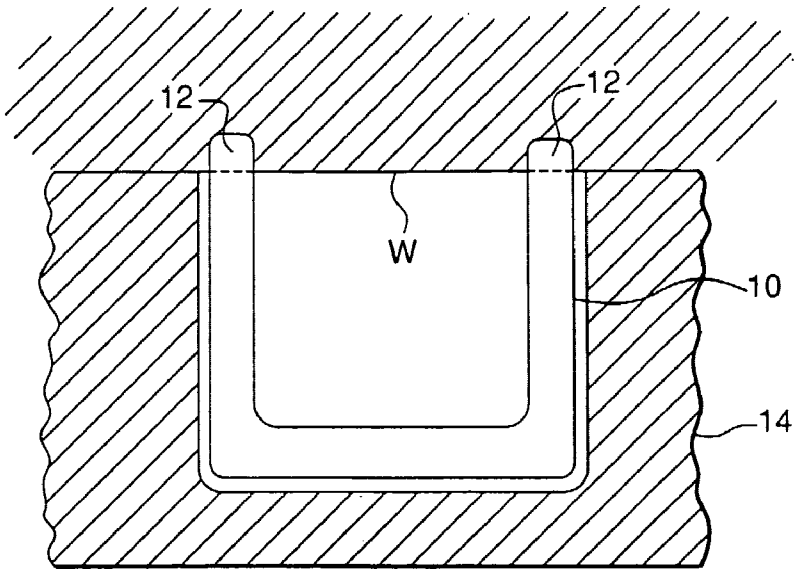


FIG. 8A
(PRIOR ART)

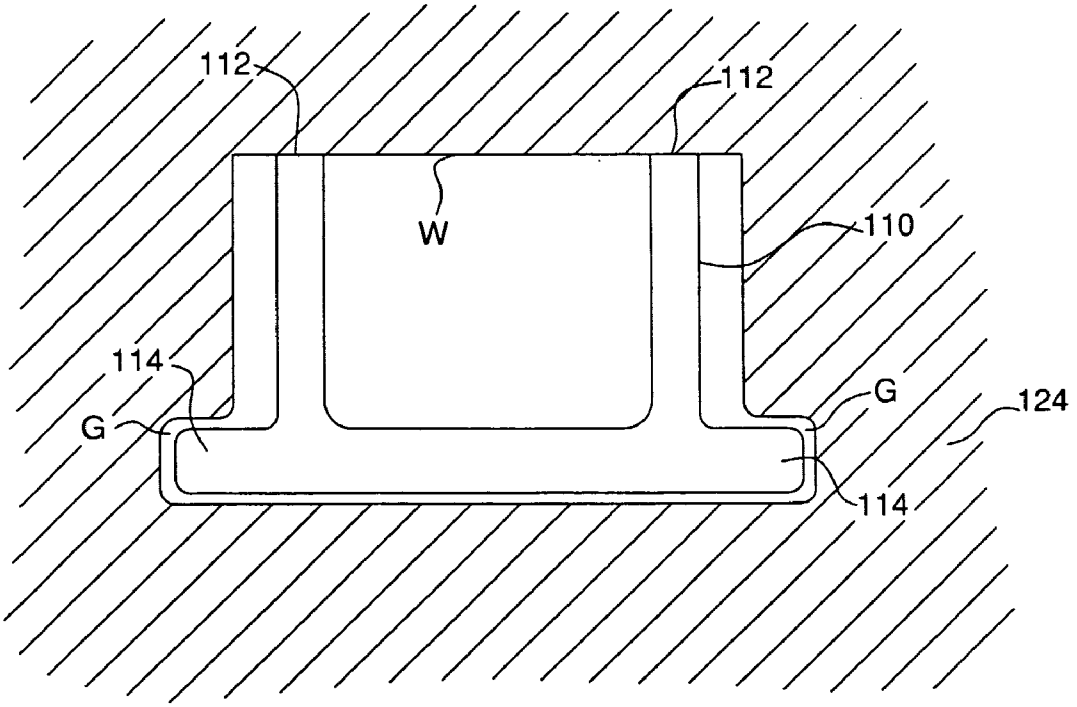


FIG. 8B

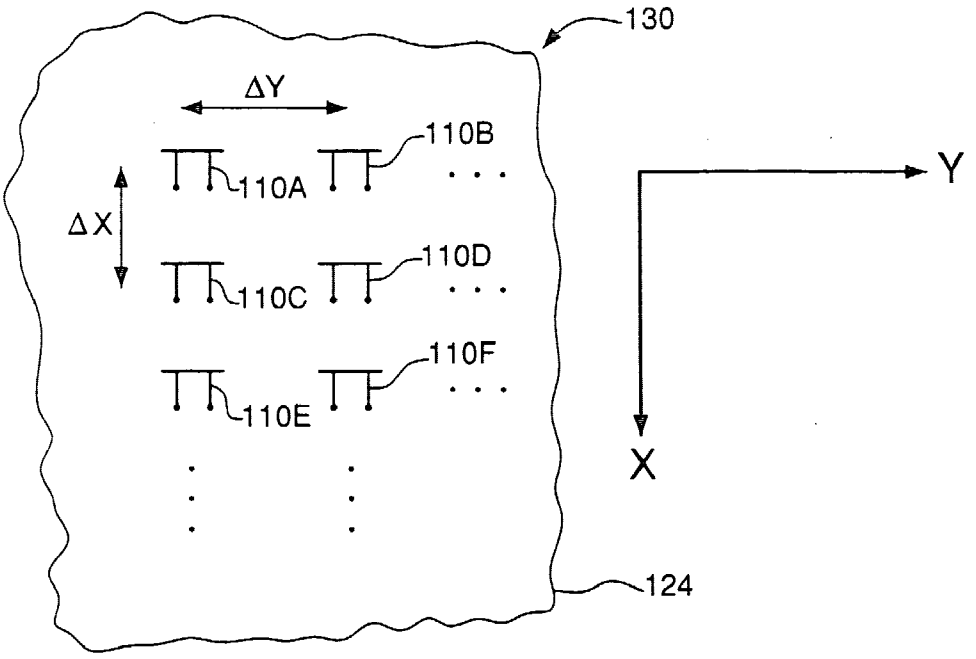

130
ΔY
110B
110A
ΔX
110D
110C
110F
110E
Y
X
124

FIG. 9

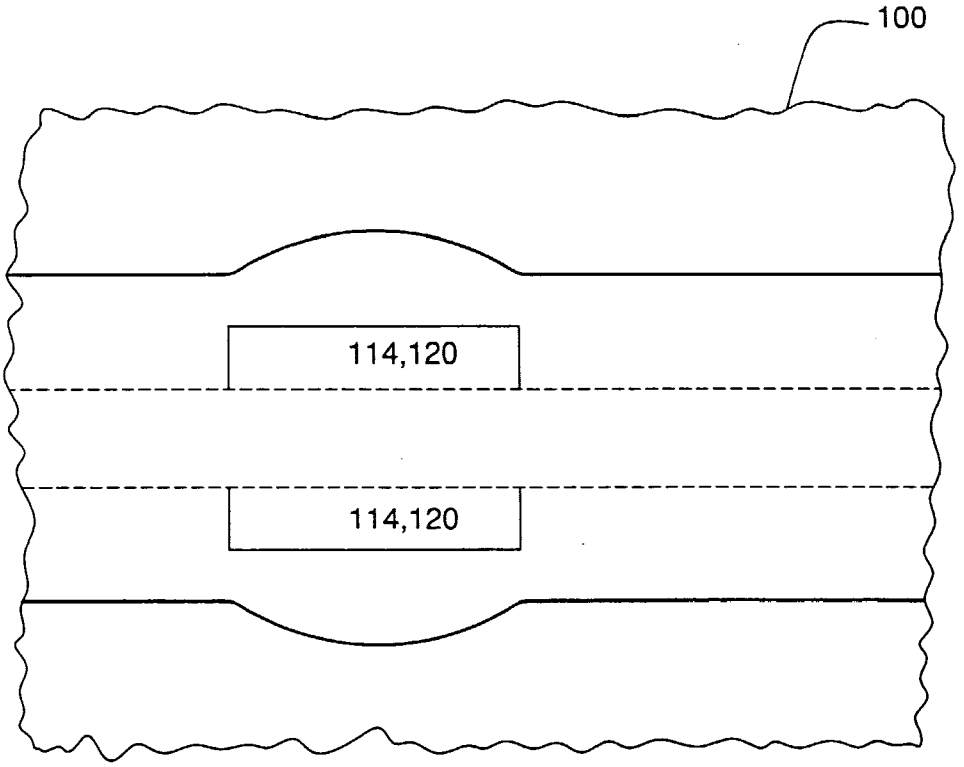

100
114,120
114,120

FIG. 10

MAINTENANCE OF UNIFORM IMPEDANCE PROFILES BETWEEN ADJACENT CONTACTS IN HIGH SPEED GRID ARRAY CONNECTORS

Applicant claims priority to U.S. provisional applications 60/384,546 filed May 30, 2002 and 60/424,143 filed Nov. 6, 2002.

FIELD OF THE INVENTION

This invention relates generally to electrical contacts that are especially suitable for use in high speed, grid array connectors. More particularly, the invention relates to electrical contacts having resilient retention members that retain the contacts within a connector base and provide for a generally uniform impedance profile between adjacent contacts.

BACKGROUND OF THE INVENTION

Typical electrical connectors comprise a connector base made of an insulating material, such as plastic, for example. A plurality of electrical contacts are retained in the connector base. In a so-called "grid array" connector, the contacts are arranged in an array. Such connectors typically include contacts that are retained in the base by virtue of respective retention members that deform the insulating material when the contact is pressed into the base.

FIG. **1** depicts a pair of typical prior art contacts **10** retained in a connector base **14**. Each contact **10** has a retention member **12**. Retention members **12** as depicted in FIG. **1** are often referred to as "barbs." When a contact **10** is pressed into the connector base **14**, the retention member **12** deforms a wall W of the base **14**. For example, the retention member **12** may penetrate the material from which the base **14** is formed. Thus, the contact **10** is retained in the base **14**.

The impedance, Z, between adjacent contacts **10** is a function of the proximity of the contacts to one another. The use of retention members such as barbs **12**, however, tends to create a so-called "impedance discontinuity" in proximity to the barb **12**. That is, the impedance Z_1 between adjacent contacts **10** as measured in proximity to the barb **12** is significantly different from the nominal impedance Z_0 between adjacent contacts **10** as measured elsewhere along the length L_1 of the portion of the contact **10** that is in the base **14** (along the x-direction as shown in FIG. **1**).

FIG. **2** is a plot of impedance Z between adjacent prior art contacts **10**, such as those depicted in FIG. **1**. As shown in FIG. **2**, a nominal impedance Z_0 exists along most of the length L of the portion of the contact **10** that is in the base **14**. In proximity to the barb **12**, however, the impedance Z between the contacts **10** drops to Z_1, where $Z_1<Z_0$. (The magnitude of the impedance discontinuity depicted in FIG. **2** is exaggerated for the purpose of explanation.)

Usually, such an impedance discontinuity is not significant enough to adversely affect the performance of the connector. As connector speeds increase into the range of about 10 Gbps and beyond, however, the discontinuity may adversely affect performance. To compound the problem, the demand for smaller connectors has required connector manufacturers to provide connectors with increasingly greater contact densities. Thus, adjacent contacts are nearer to one another. In such high speed, high density connectors, uniform impedance between adjacent contacts becomes ever more important.

It would be advantageous, therefore, to manufacturers and users of such high speed, high density connectors if there were available electrical contacts that could be adequately retained in the connector base, while maintaining an impedance profile (i.e., impedance between adjacent contacts as measured along the lengths of the portions of the contacts that are in the base) that is generally uniform (i.e., nearly constant) along the lengths of the portions of the contacts that are in the base.

SUMMARY OF THE INVENTION

The invention provides electrical contacts that have a retention member extending along a length of the contact. The contact may include a receptacle end adapted to receive a complementary electrical contact, and an insertion end adapted to be inserted into a connector base.

The retention member is adapted to retain the contact within a connector base and to deform upon insertion of the contact into the base to cause a generally straight edge to be formed along a portion of the contact. The retention member may be adapted to retain the contact within the connector base by creating a normal force between the contact and a wall of the connector base sufficient to retain the contact in the connector base, without deforming the wall of the connector base.

The retention member may include a beam portion that is adapted to deform, upon insertion of the contact into the connector base, to form the generally straight edge along the portion of the contact. The retention member may also include a gap proximate the beam portion that enables the beam portion to deform upon insertion of the contact into the connector base.

The contact may include a deflection member that extends from the beam portion and is adapted to retain the contact within the connector base by creating the normal force between the contact and the wall of the connector base. The deflection member may be adapted to deform the beam portion, upon insertion of the contact into the connector base, to form the generally straight edge along the portion of the contact.

The contact may include a guide member extending along a second portion thereof. The guide member may be adapted to be received into a groove in the connector base. The guide member may have a shoulder via which the contact can be pressed into the connector base. Where the contact is formed by bending a sheet of conductive material, the guide member may be formed from a portion of the sheet that is displaced to form the gap.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is further described in the accompanying drawings in which:

FIG. **1** depicts a pair of typical prior art contacts retained in a connector base;

FIG. **2** is a plot of impedance between adjacent prior art contacts, such as those depicted in FIG. **1**;

FIG. **3** is a partial perspective view of a preferred embodiment of a contact according to the invention;

FIG. **4** is a longitudinal view of a preferred embodiment of a contact according to the invention;

FIG. **5** is a detailed view of a preferred embodiment of a resilient retention member according to the invention;

FIG. **6** depicts a pair of contacts according to the invention retained in a connector base;

FIG. **7** is a plot of a impedance between adjacent contacts according to the invention, such as those depicted in FIG. **6**;

FIGS. **8**A and **8**B provide cross-sectional views of a typical prior art contact and a contact according to the invention, respectively;

FIG. **9** depicts a connector base having an array of contacts according to the invention retained therein; and

FIG. **10** depicts die-cutting and folding patterns for forming a contact according to the invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

FIG. **3** is a partial perspective view, and FIG. **4** is a longitudinal view, of a preferred embodiment of a contact **110** according to the invention. As shown, the contact **110** may include a receptacle portion **122** that is adapted to receive a complementary electrical contact (not shown), an insertion portion **124** that is adapted to be inserted into a connector base (see FIG. **6**), and a plate portion **128** connecting the receptacle portion **122** with the insertion portion **124**. As shown, the insertion portion **124** can include a compliant "eye in the needle" fit feature. A beam portion of the contact **117** extends between the receptacle portion and the insertion portion. As shown in FIGS. **3** and **4**, the beam portion **117** may include two beam members **117**A, **117**B.

The contact **110** includes a retention member **112** extending at an angle (e.g., generally perpendicular) to the plate portion **128** along a length L of the plate portion **128** between the receptacle portion **122** and the insertion portion **124**. The retention member **112** is adapted to retain the contact **110** within the connector base, and to deform upon insertion of the contact **110** into the base to cause a generally straight edge to be formed along the portion of the contact that is inserted into the base. The generally straight edge provides a generally uniform impedance profile between adjacent contacts in the connector. As shown, the contact **110** may include more than one retention member **112**, each extending along a respective length of the contact **110**.

In a preferred embodiment, the retention member **112** has a resilient beam portion **116** that is adapted to deform, upon insertion of the contact **110** into the connector base, to form the generally straight edge. The contact **110** may include a gap **120** proximate the resilient beam portion **116**. The gap **120** allows for resiliency (or "springing action") in the beam portion **116** and thus encourages the beam portion **116** to deform upon insertion of the contact **110** into the connector base. A deflection member **118** may extend from the beam portion **116**. The deflection member **118** is adapted to deform the resilient beam portion upon insertion of the contact into the connector base.

The contact **110** may also include a guide member **114** extending along a portion of the contact **110**. The guide member **114** provides additional stability to the contact **110** to prevent deformation of the contact **110** upon insertion of the contact **110** into the base **124**. Preferably, the guide member **114** is adapted to be received into a groove in the connector base. As shown, the guide member **114** may have a shoulder **114**A via which the contact **110** may be pressed into the connector base **124**. The shoulder **114**A aids in carrying the load of the force required to press the contact **110** into the base **124**. In a preferred embodiment, the retention member **112** extends in a first direction along the length of the contact (x-direction as shown in FIG. **3**), while the guide member **114** extends in a second direction (y-direction as shown in FIG. **3**) that is generally orthogonal to direction in which the retention member extends.

FIG. **5** is a detailed view of a preferred embodiment of a resilient retention member **112** according to the invention. A typical beam member **117**B of the contact **110** has a thickness t. Preferably, as described below in connection with FIG. **10**, the contact is stamped from a sheet of electrically conductive material. It should be understood that the thickness of the beam member **117**B may be determined by the thickness of the material from which the contact stamped.

The retention member **112** extends along a length L of the beam member **117**B. The resilient beam portion **116** of the retention member **112** has a width w. The gap **120** has a gap width a and a gap length l. The deflection member **118** extends a distance d from the beam member **117**B.

Though the resilient beam portion **116** and gap **120** can have any shape, it is preferred that the beam portion **116** is bowed somewhat to foster resiliency in the retention member **114**. Thus, the beam portion acts like a spring that is "compressed" upon insertion into the connector base **124**. The specific geometry of the retention member **114** (e.g., of the resilient beam portion **116** and gap **120**) can be determined for a given application (e.g., the desired size and shape of the contact; the proximity of contacts to each other; the materials used to form the contact and connector base).

FIG. **6** depicts a pair of contacts **110** according to the invention retained in a connector base **124**. Each contact **110** has a resilient retention member **112**. As shown, upon insertion of the contact **110** into the connector base **124**, the retention member **112** deforms to cause a generally straight edge E to be formed along the portion of the contact **110** within the connector base **124**. The deflection member **118** causes the resilient beam portion **116** to deform while creating a normal force N between the contact **110** and the connector base **124**. The normal force N is sufficient to retain the contact **110** in the connector base **124** without significantly deforming the wall W of the connector base **124**. Thus, the contact **110** is retained in the connector base **124** and a generally uniform impedance profile is created along the portion of the contact **110** that is within the base **124**.

The compressive strength (a.k.a., yield strength) of the material used to form the base should also be considered in determining the geometry of the retention member **114**. The connector base **124** can be made of reinforced engineering polymers, for example, the compressive strengths of which are well-known and typically within the range of about 15,000 psi to 25,000 psi. It is anticipated that, in a typical application, a normal force of about 10–15 pounds will ensure that the contact will be retained in the connector base **124**.

The pressure the contact exerts on the wall W of the connector base **124** is a function of the surface area of the portion of the retention member **114** that makes contact with the wall W (e.g., the surface area of the deflection member **118**) and the normal force N it exerts on the wall W. The surface area of the deflection member **118**, for example, can be chosen so that the normal force is sufficient to retain the contact in the base but create pressure below the yield strength of the wall W so as not to deform the wall W (i.e., so that the edge is generally straight and, therefore, the impedance profile is generally uniform). Though the deflection member **118** may, in general, have any shape, it is preferred that the deflection member **118** have a shape that is generally semicircular or generally elliptical. The displacement d of the deflection member **118** (measured from the beam portion **116** to point of contact with wall of the connector base) is expected to be about 5 mil.

FIG. **7** is a plot of a impedance Z between adjacent contacts according to the invention, such as those depicted

in FIG. **6**. As shown in FIG. **7**, the impedance profile is generally uniform. That is, the impedance Z between adjacent contacts is nearly constant (i.e., Z_0) along the length of the portion of the contact that is in the base.

FIGS. **8**A and **8**B provide cross-sectional views of a typical prior art contact **10** and a contact **110** according to the invention, respectively. As shown in FIG. **8**A, a typical prior art contact **10** has a retention member that includes a barb **12**. The barb **12** penetrates the wall W of the connector base **14**. Thus, an impedance discontinuity is formed between adjacent contacts in the area of the barb **12**.

By contrast, a contact **110** according to the invention includes a retention member **112** that deforms upon insertion into the connector base **124** to form a generally straight edge along the portion of the contact **110** that is within the base **124**. As shown in FIG. **8**B, a contact **110** according to the invention can also include a guide member **114** adapted to be received into a groove G in the connector base **124**. The optional guide members **114** may extend from the beam portion of the contact **110** and aid in the insertion of the contact **110** into the base **124**.

FIG. **9** depicts a typical grid array electrical connector **130** having an array of contacts **110***a*–**110***e* (generally **110**) retained in a connector base **124**. Each of the contacts **110** includes one or more retention members extending along respective lengths thereof. Each of the retention members exerts a normal force that retains the respective contact **110** within the connector base **124**. Because the retention members deform upon insertion of the contacts **110** into the base **124**, each has a generally straight edge along the portions of the contacts that include the lengths along which the retention members extend. Consequently, a generally uniform impedance profile exists between adjacent contacts **110** along the respective portions that are inserted into the connector base **124**.

As shown in FIG. **9**, the contact array has a row pitch ΔX and a column pitch ΔY. It is expected that, in typical applications, the row pitch ΔX will be larger than the column pitch ΔY. Accordingly, the contacts can be arranged with the deflection members disposed along the columns of the array (i.e., the x-direction as shown in FIG. **9**), and the optional guide members disposed along the rows of the array (i.e., the y-direction as shown in FIG. **9**).

Preferably, a contact according to the invention may be made by die-cutting and folding a sheet of conductive material. The material may be any suitable electrically conductive material, such as brass, phosphor bronze, or beryllium copper, for example.

FIG. **10** depicts cutting and folding patterns for forming a contact according to the invention from a sheet of electrically conductive material **100**. The solid lines depict the cutting pattern. The dotted lines depict fold lines. The contact may be cut (by die-cutting with a progressive die, for example) along the solid lines and folded along the dotted lines. Techniques for cutting and folding sheets of electrically conductive material are well-known are, therefore, are not described in detail herein.

As shown in FIG. **10**, a guide member **114** may be formed from the portion of the sheet that is displaced during formation of the gap **120**. Alternatively, the contact **110** can be made without a guide member by simply stamping a gap in the sheet before folding (i.e., by discarding the portion of the sheet from which the gap **120** is formed).

Though the invention has been described herein in connection with certain currently preferred embodiments shown in the several figures, it should be understood that other similar embodiments may be used or modifications and additions may be made to the described embodiments for practicing the invention without deviating therefrom. Therefore, the invention should not be limited to any particular embodiments, but rather construed in breadth and scope in accordance with the recitation of the appended claims.

We claim:

1. An electrical contact, comprising:

a plate portion; and

a retention member extending at an angle to the plate portion along a length of the plate portion, the retention member being adapted to retain the contact within a connector base and comprising a gap that enables the retention member to deform upon insertion of the contact into the base to cause a generally straight edge to be formed along a portion of the contact that includes the length along which the retention member extends.

2. The contact of claim **1**, wherein the retention member is adapted to retain the contact within the connector base by creating, between the contact and a wall of the connector base, a normal force sufficient to retain the contact within the connector base.

3. The contact of claim **1**, wherein the retention member is adapted to retain the contact within the connector base by creating, between the contact and a wall of the connector base, a normal force sufficient to retain the contact in the connector base without deforming the wall of the connector base.

4. The contact of claim **1**, further comprising a guide member extending along a second portion of the contact, the guide member being adapted to be received into a groove in the connector base.

5. The contact of claim **4**, wherein the guide member has a shoulder via which the contact can be pressed into the connector base.

6. The contact of claim **4**, wherein the retention member extends in a first direction along the length of the plate portion and wherein the guide member extends in a second direction that is generally orthogonal to first direction.

7. The contact of claim **1**, further comprising a second retention member extending at an angle to the plate portion along a length of the plate portion, the second retention member being adapted to retain the contact within the connector base and to deform upon insertion of the contact into the base to cause a generally straight edge to be formed along a second portion of the contact that includes the length along which the second retention member extends.

8. An electrical contact, comprising:

a receptacle end adapted to receive a complementary electrical contact,

an insertion end adapted to be inserted into a connector base,

a plate portion extending between the receptacle end and the insertion end; and

a retention member extending at an angle to the plate portion along a length of the plate portion between the receptacle end and the insertion end, the retention member having a resilient beam portion and a deflection member extending from the beam portion, the retention member comprising a gap extending through the retention member, wherein the resilient beam portion deforms into the gap upon insertion of the contact into the connector base to form a generally straight edge along a portion of the contact that includes the length along which the retention member extends.

9. The electrical contact of claim **8**, wherein the deflection member is adapted to retain the contact within the connector

base by creating a normal force between the contact and a wall of the connector base sufficient to retain the contact in the connector base.

10. The electrical contact of claim **8**, wherein the deflection member is adapted to deform the resilient beam portion, upon insertion of the contact into the connector base, to form the generally straight edge along the portion of the contact that includes the length along which the retention member extends.

11. The contact of claim **8**, wherein the gap is disposed proximate the resilient beam portion.

12. The contact of claim **11**, further comprising a guide member extending along a second portion of the contact, the guide member being adapted to be received into a groove in the connector base.

13. The contact of claim **12**, wherein the contact is formed by bending a sheet of conductive material and the guide member is formed from a portion of the sheet that is displaced to form the gap.

14. An electrical connector comprising:

a connector base;

a first electrical contact having a portion thereof inserted into the connector base, the portion comprising a plate portion and a retention member extending at an angle to the plate portion; and a second electrical contact having a portion thereof inserted into the connector base, the second electrical contact being disposed adjacent to the first electrical contact,

wherein the retention member comprises a gap extending through the retention member that enables the retention member to deform upon insertion of the first electrical contact into the connector base to cause a generally straight edge to be formed along the portion of the first electrical contact inserted into the connector base such that a generally uniform impedance profile exists between the first and second electrical contacts along the respective portions that are inserted into the connector base.

15. The electrical connector of claim **14**, wherein each of the first and second electrical contacts comprises a respective retention member that exerts a respective normal force that retains the respective contact within the connector base.

16. The electrical connector of claim **15**, wherein each of the respective retention members has a generally straight edge along a portion of the respective contact that includes the respective length along which the respective retention member extends.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 7,018,246 B2
APPLICATION NO. : 10/388966
DATED : March 28, 2006
INVENTOR(S) : Alan Raistrick and Joseph B. Shuey

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

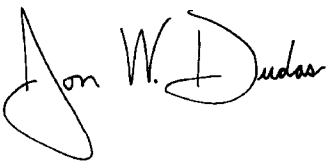
On the title page:

At **(60) Related U.S. Application Data** (on front page of patent): delete entire paragraph

At **Col. 1, lines 6-8** (first paragraph beneath the Title): delete entire paragraph

Signed and Sealed this

Eighteenth Day of March, 2008



JON W. DUDAS
Director of the United States Patent and Trademark Office